Outflow and Mass Flow: What is Needed from the Magnetosphere Community

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1. Spatial and Temporal Resolutions

Mesoscale (100-1000 km) Structures are Common in Ionosphere and Thermosphere

The Dominant Mass, Momentum, and Energy Coupling in the M-I-T System May be at These and Smaller Scales

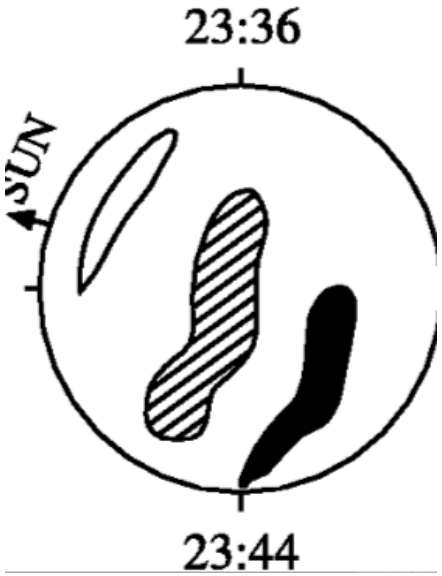
Mesoscale I-T Structures (100-1000 km)

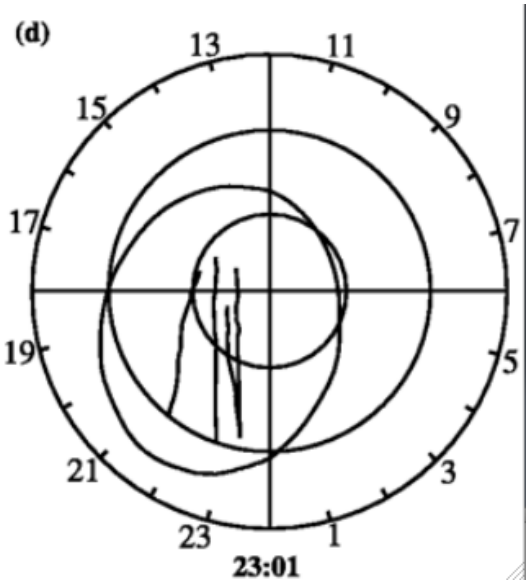
- **Propagating Plasma Patches**
- **Propagating Atmospheric Hole**
- **Propagating Polar Wind Jets**
- **Propagating Neutral Streams**
- **Sun-Aligned Polar Cap Arcs**
- **Theta Aurora**
- **Boundary and Auroral Blobs**
- **Stationary Polar Wind Jets**
- **Neutral Polar Wind Streams**
- **Sub-Auroral Ion Drift Events (SAID)**
- **Storm Enhanced Densities (SED) Ridges**

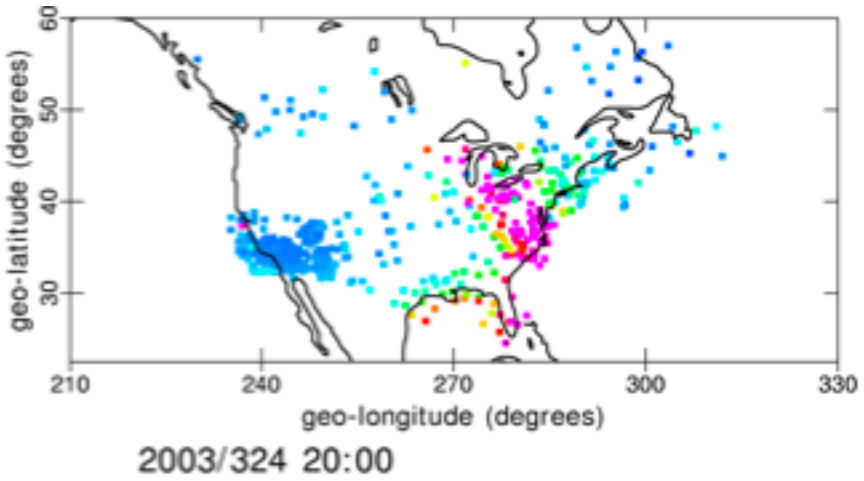
Causes of Plasma Structures

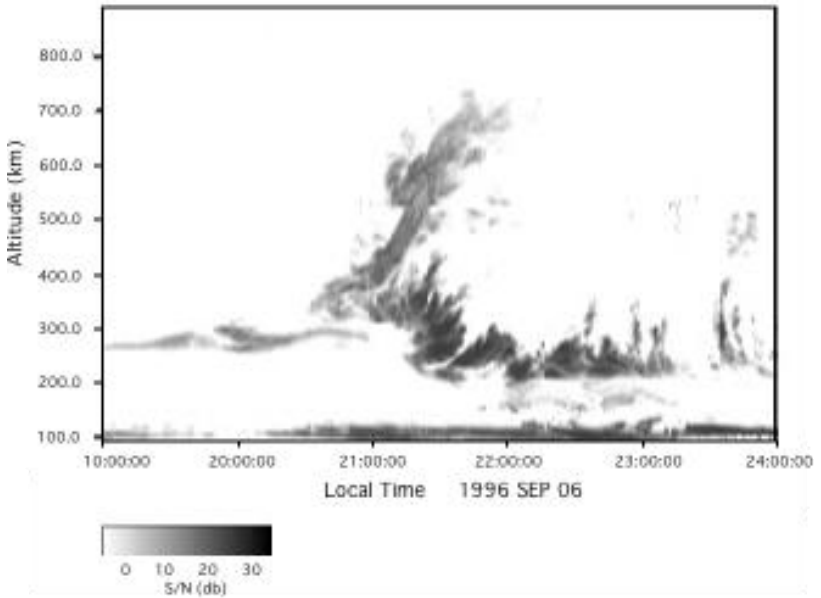
- **Changes in the Solar Wind Drivers**
- **Structured Electric Fields**
- **Structured Particle Precipitation**
- **Time Variations in E-fields and Precipitation**
- **Time Delays and Feedback Mechanisms in the M-I-T System**
- **Plasma Instabilities**

Examples of I-T Structures

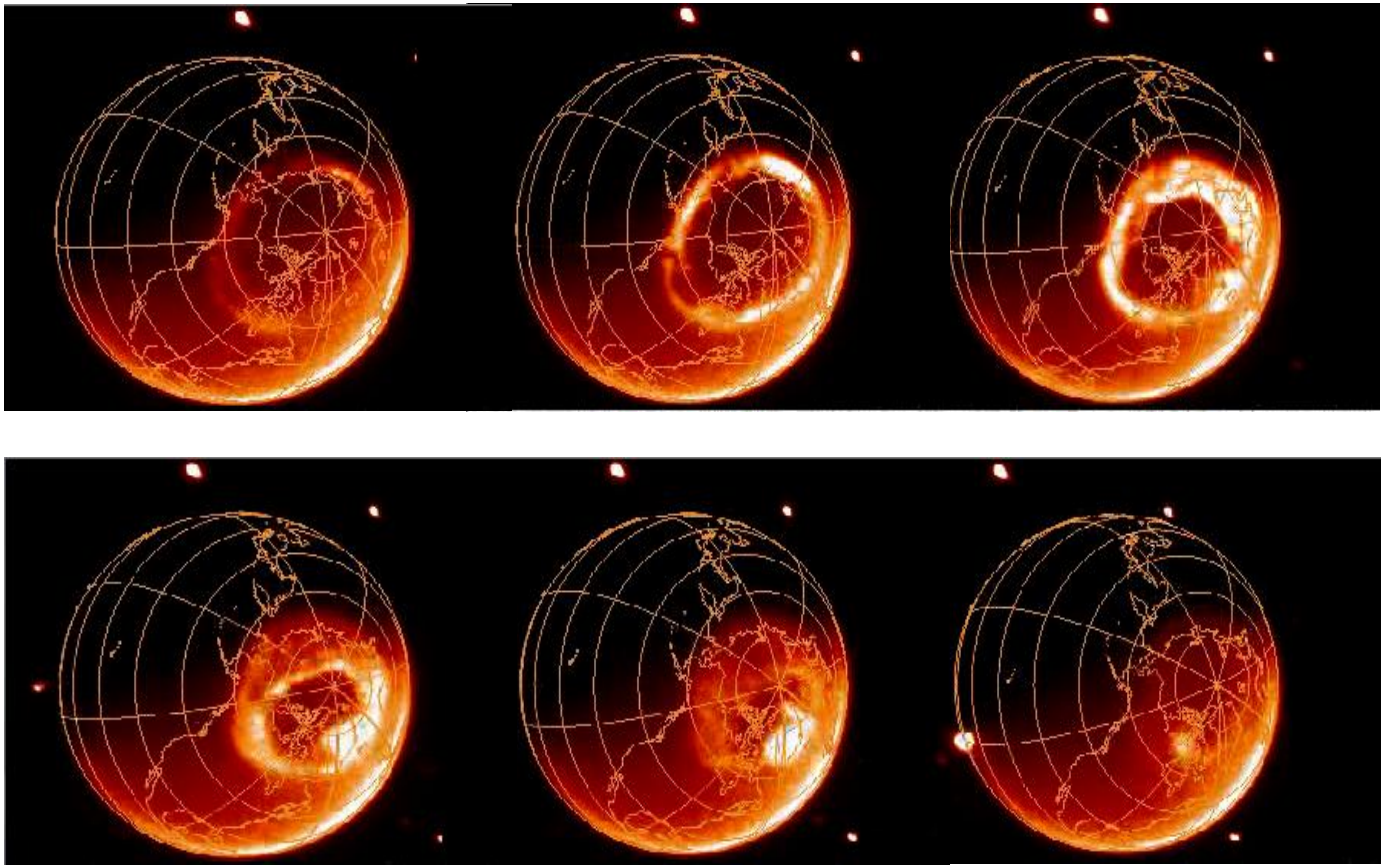








Temporal Resolution



Burch, J. L., *Scientific American, 284*, 72-80, 2001

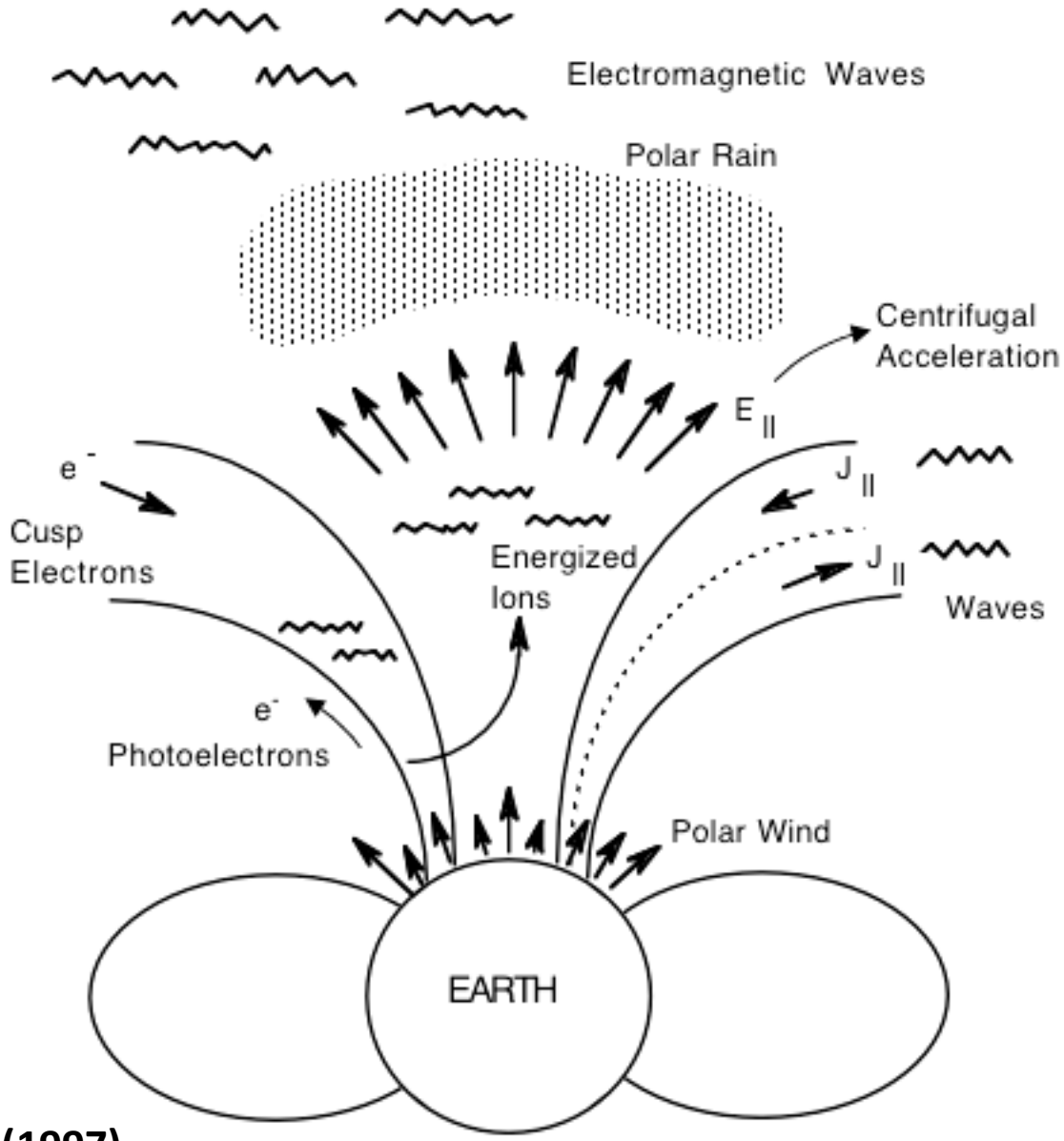
- Bastille Day Storm
- July 14-15, 2000
- Snapshots During a 1-Hour Period

Spatial and Temporal Resolutions Needed from the Magnetosphere Community

Convection, Precipitation & Currents

20 km Spatial Resolution and 1 Minute Temporal Resolution

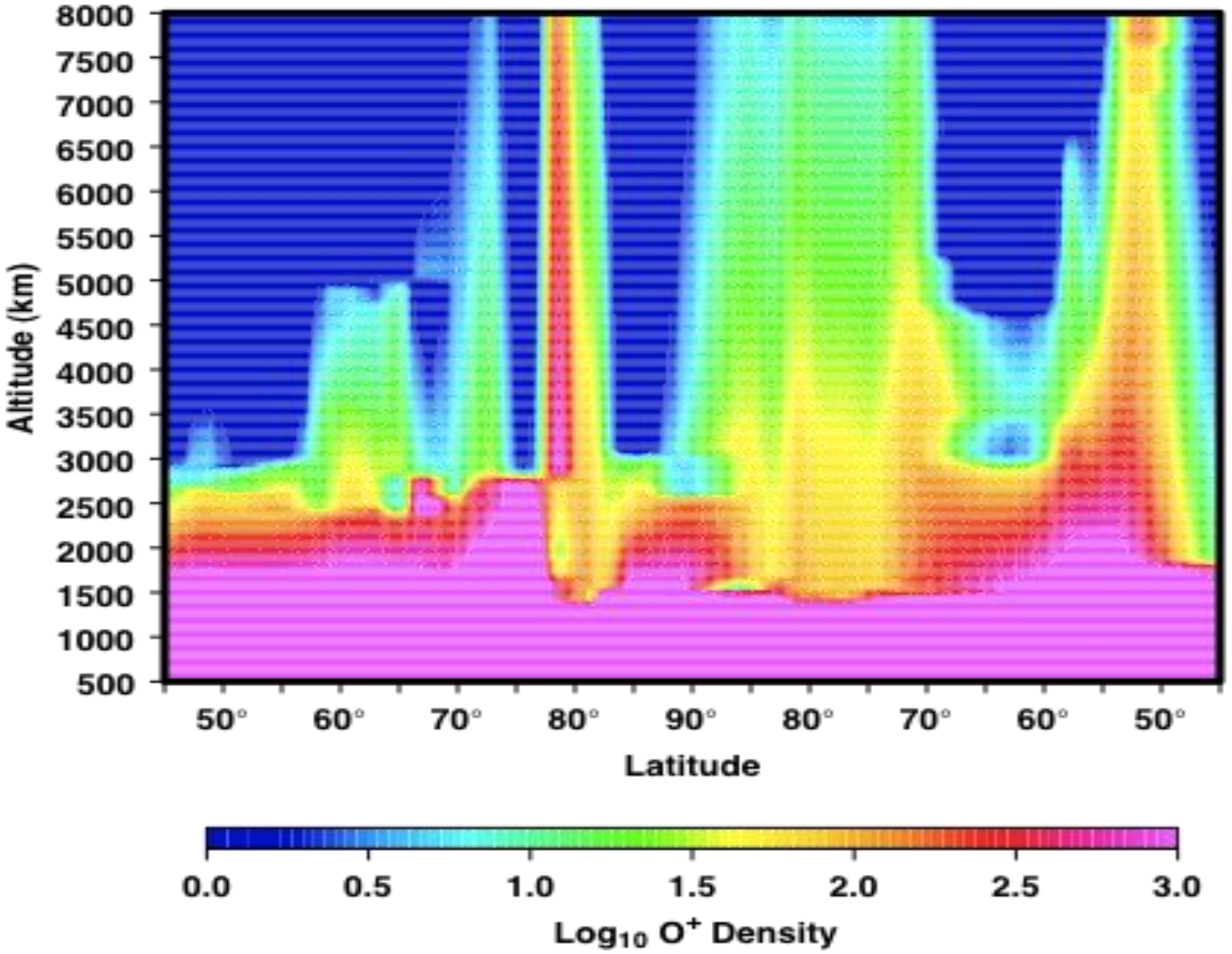
2. Continuous Loss Due to Ion & Neutral Outflow



Schunk & Sojka (1997)

End of Main Phase

Winter - Solar Maximum



Demars & Schunk (2003)

End of Main Phase

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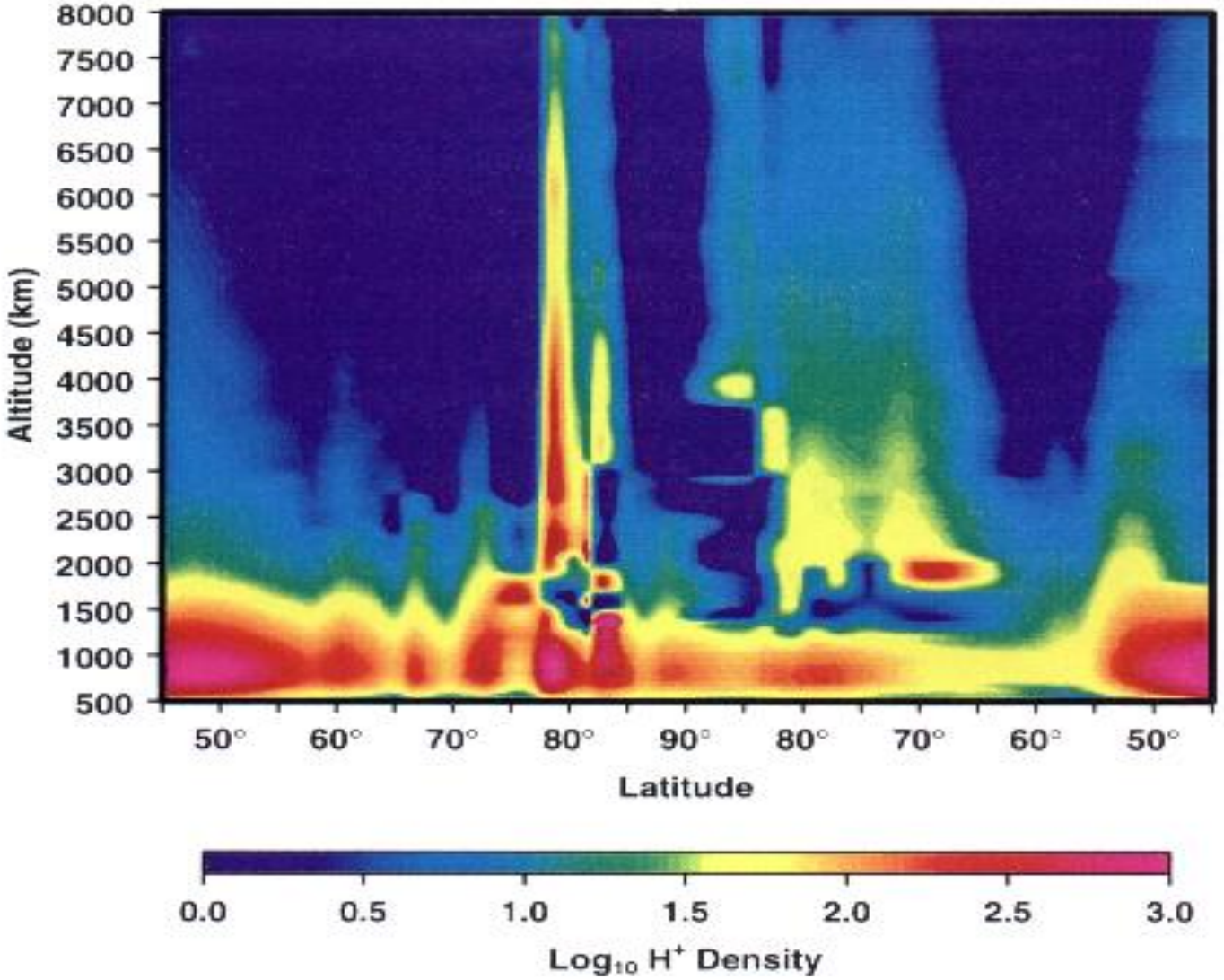
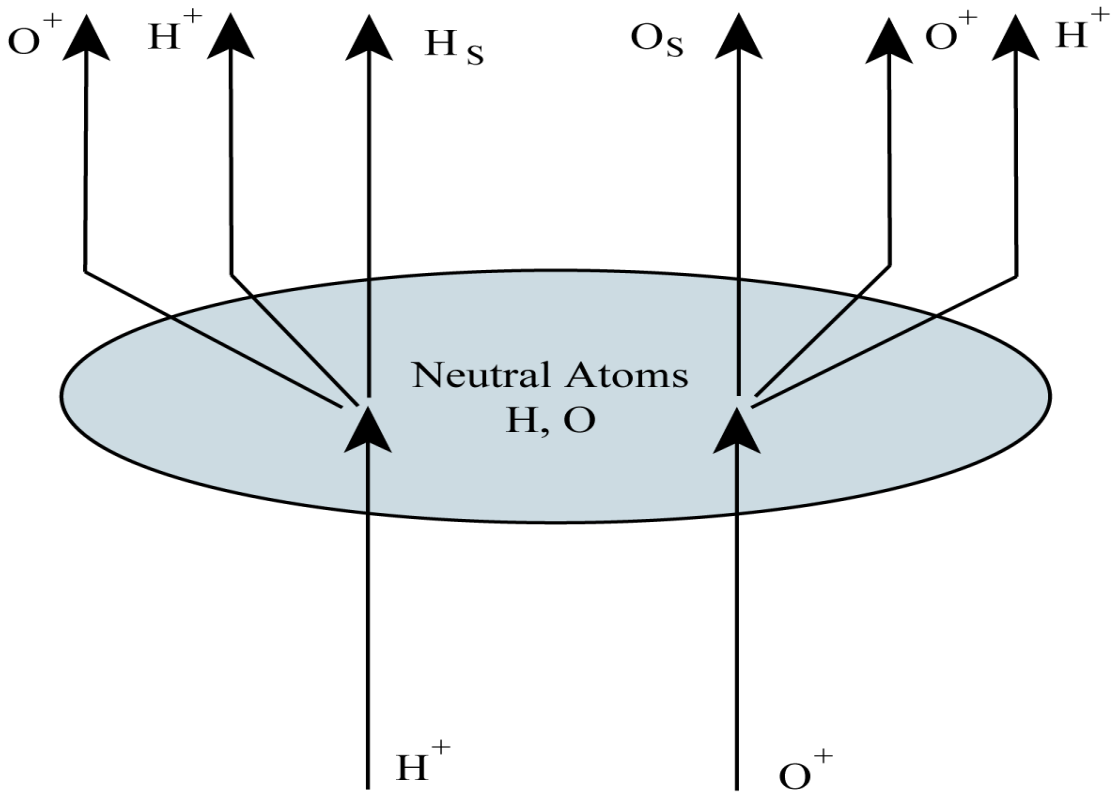


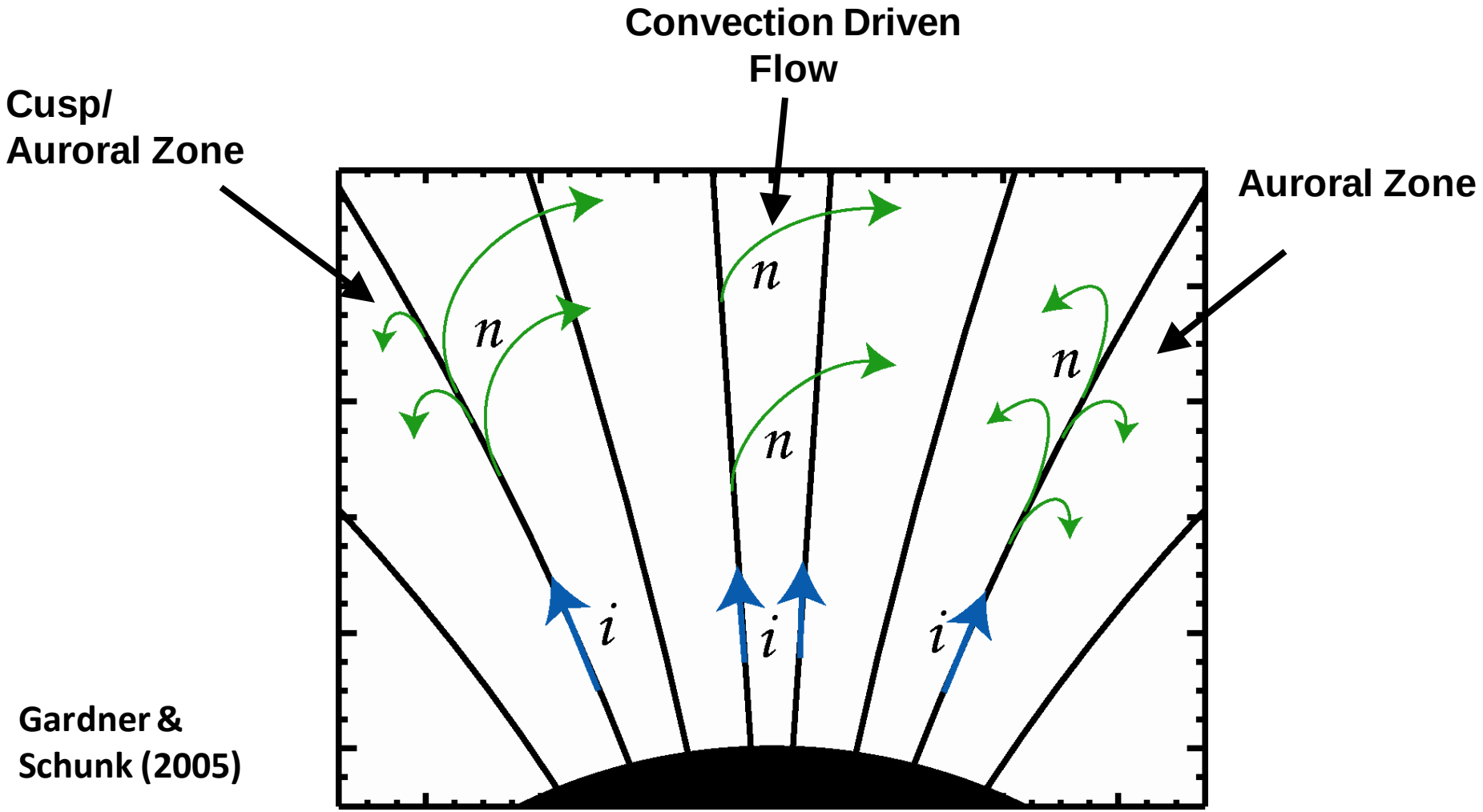
Demars & Schunk (2003)

Neutral Polar Wind



Gardner and Schunk (2004)

Neutral Polar Wind
H_S Escape Flux = 10^9 cm^{-2} s^{-1}



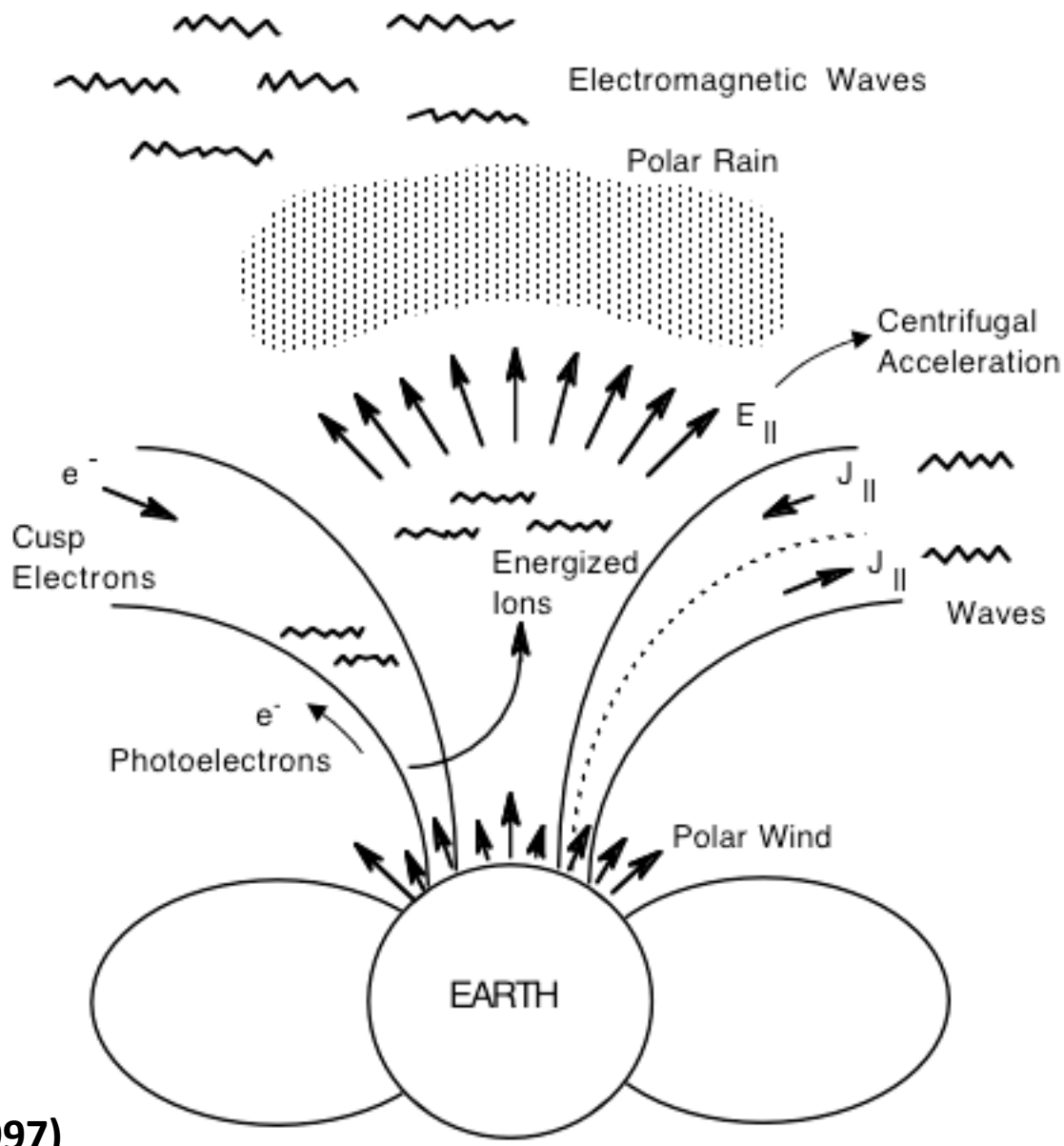
Gardner & Schunk (2005)

What is Needed from the Magnetosphere Community

Why do we have Oceans?

Need to Separately Model H^+ (solar wind), H^+ (polar wind) and H_S (neutral polar wind)

3. Ionosphere – Magnetosphere Electron Interactions



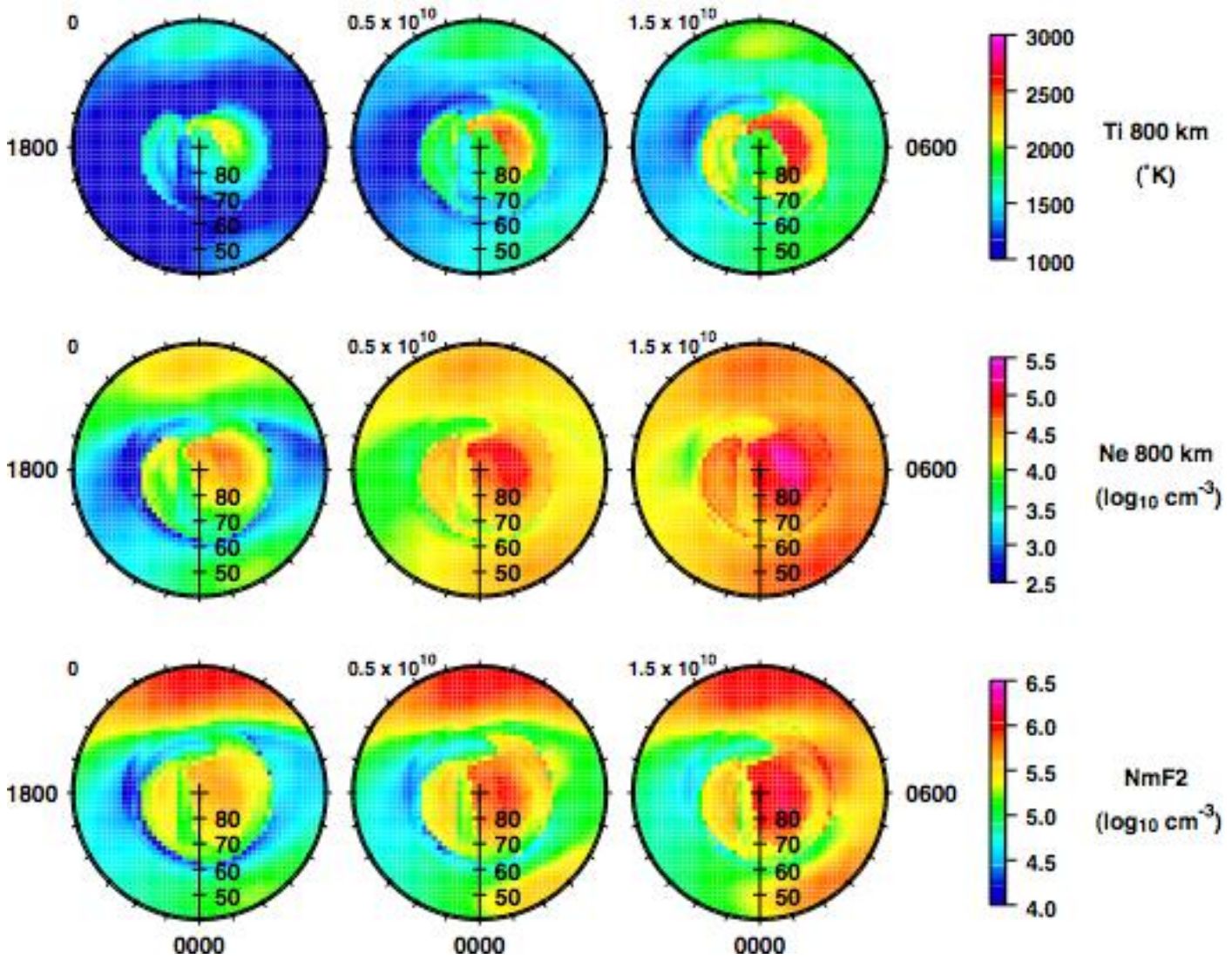
Schunk & Sojka (1997)

Winter
(day = 357)

Solar Medium
(F10.7 = 160)

Quiet
(Kp=2)

0500 UT



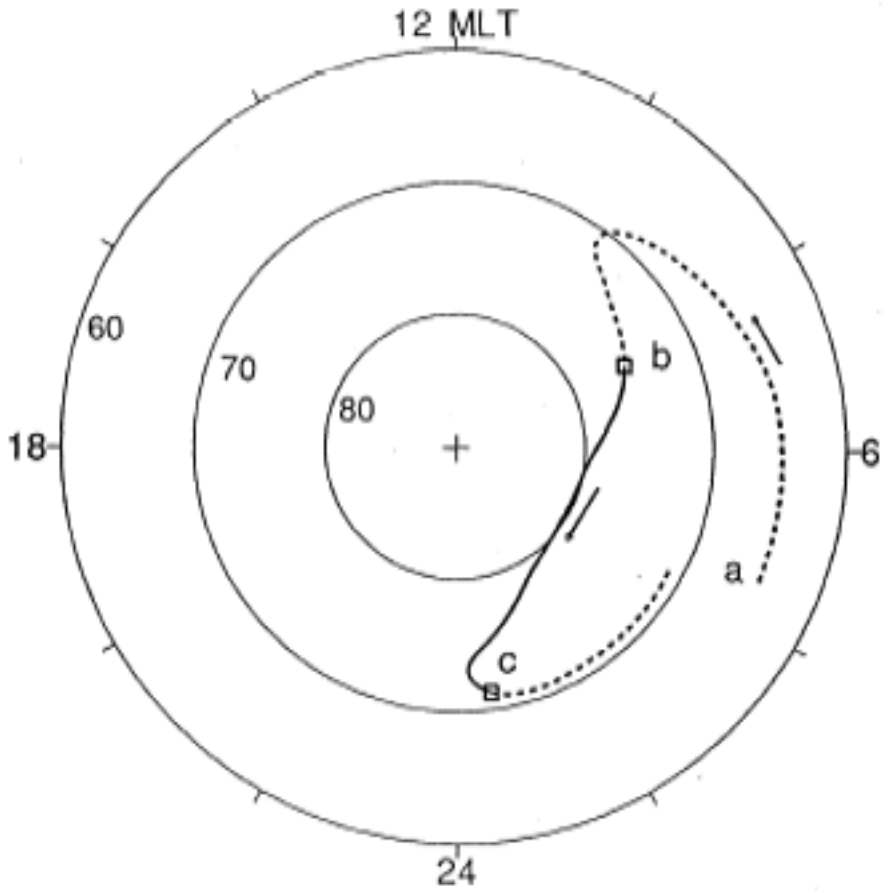
Q_T = 0.0 0.5 1.5 x 10^{10} eV cm^{-2} s^{-1}

David et al (2010)

Downward Electron Heat Flow

Hot-Cold Electron Contact Potential

Selected Trajectory



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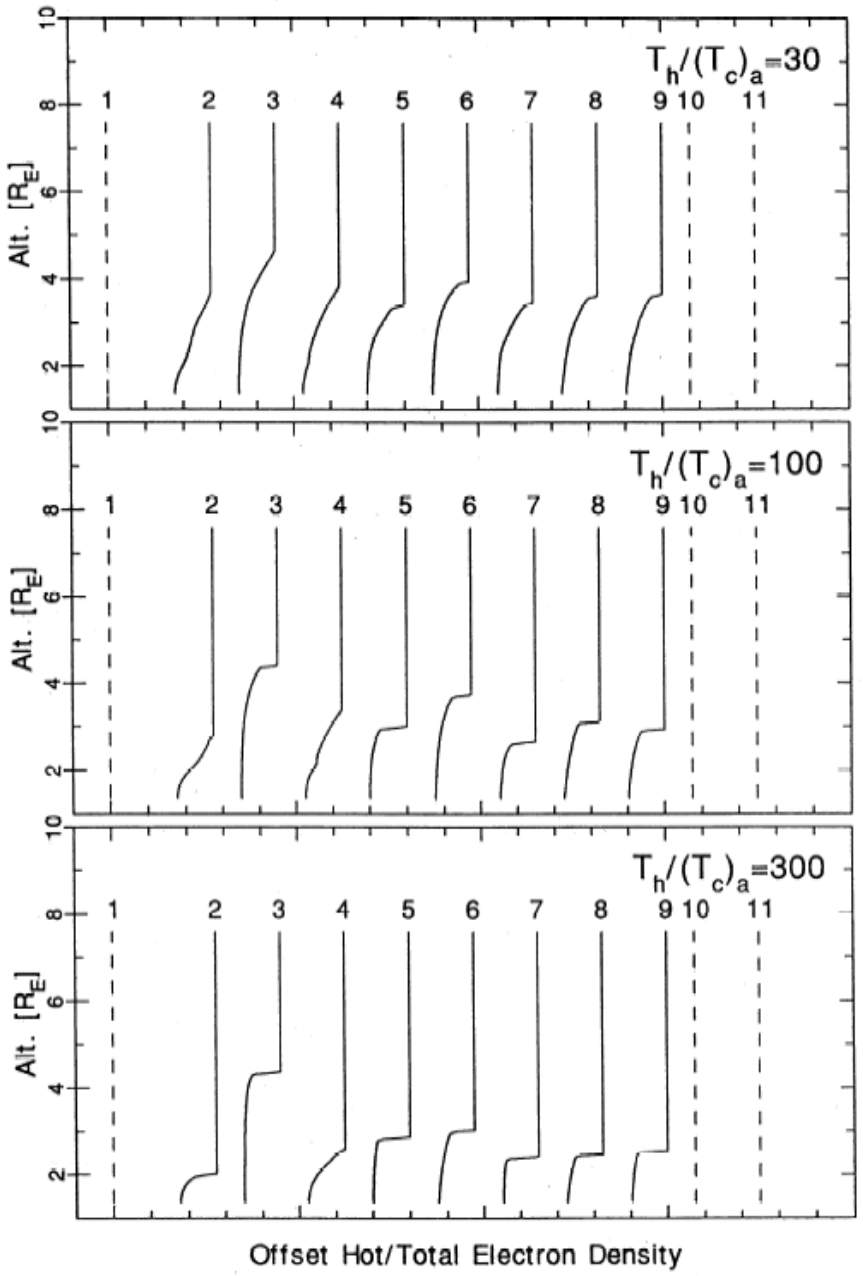
Hot/Total Electron Density Ratio

Contact Potential (Double Layer)



30

100

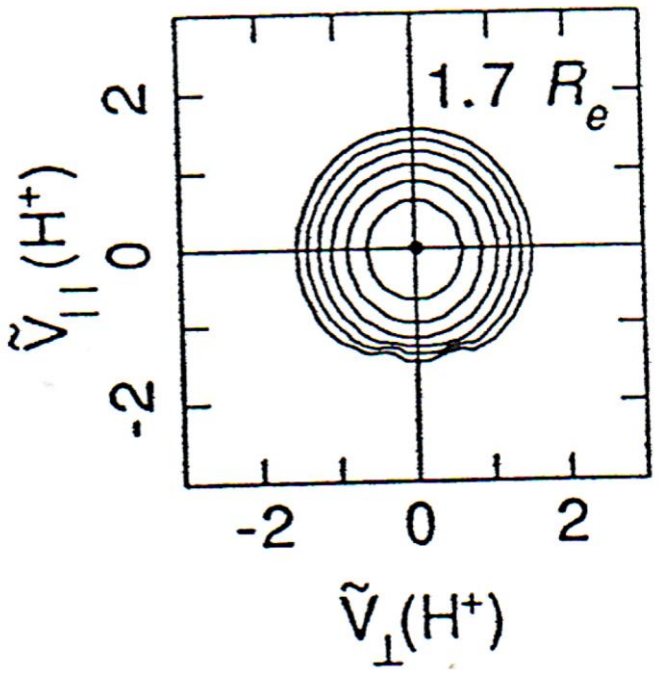
300

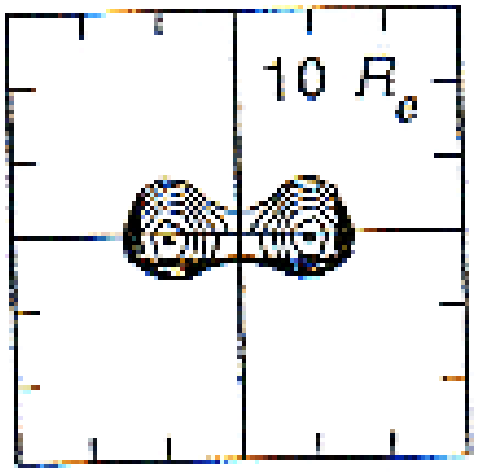
What is Needed from the Magnetosphere Community

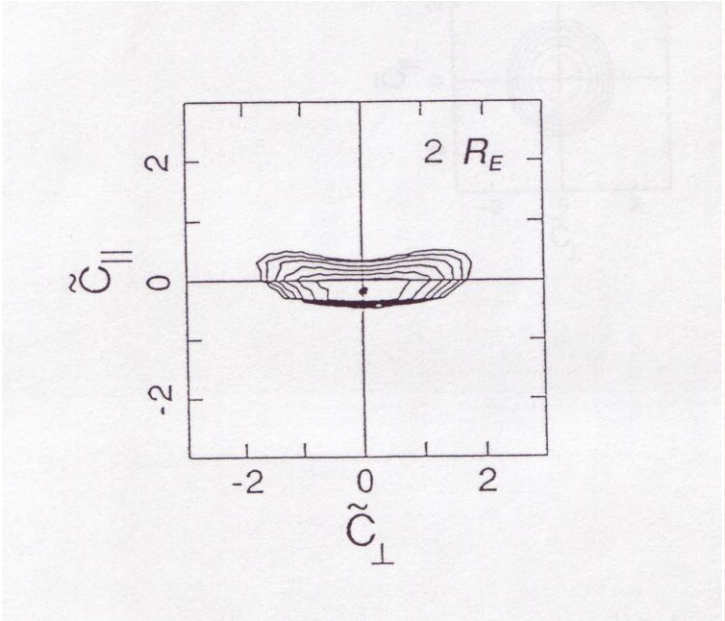
Need to Separately Model the Different Hot Electron Populations (Polar Rain, Squall & Drizzle)

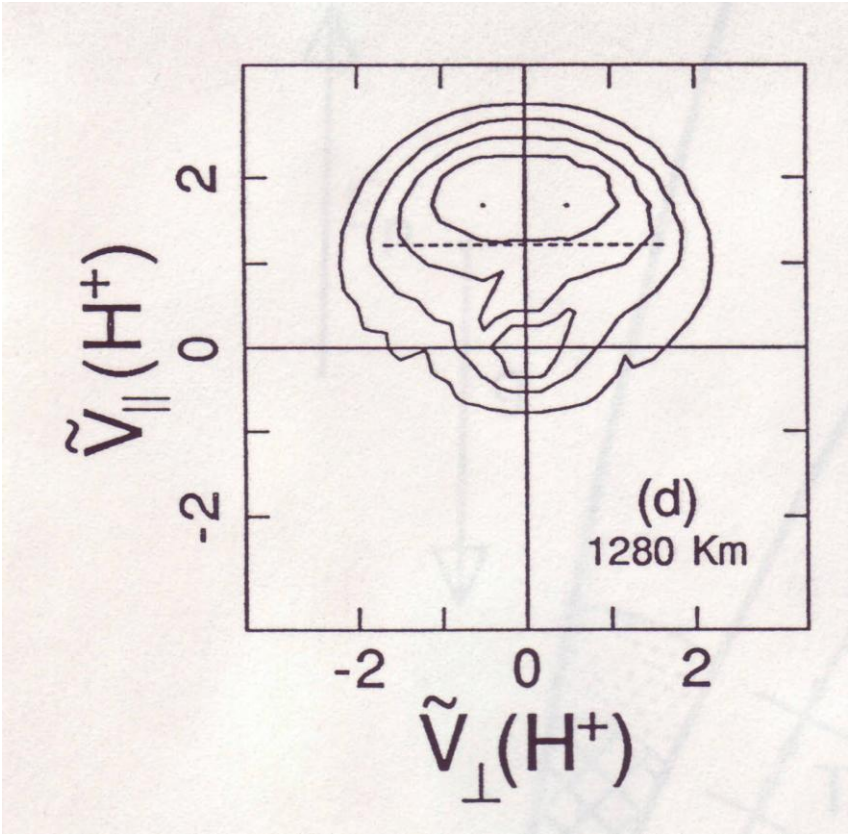
4. Ion Outflow Velocity Distributions are Non-Maxwellian

- **Beams**
- **Bi-Maxwellian**
- **Asymmetric with Elongated Tails**
- **Double-Peak**
- **Pancake**
- **Conic**
- **Counter-streaming Ions**


1.7 R_e
$\tilde{V}_{||}(H^+)$
$\tilde{V}_{\perp}(H^+)$
2
0
-2


10 R_e


2 R_E
$\tilde{C}_{||}$
$\tilde{C}_{\perp}$
2
0
-2


$\tilde{V}_{||}(H^+)$
$\tilde{V}_{\perp}(H^+)$
(d)
1280 Km
2
0
-2

What is Needed from the Magnetosphere Community

Need to Determine the Stability of the Magnetosphere in the Presence of Non-Maxwellian Polar Wind Velocity Distributions

5. Global MHD Magnetosphere Models

- **Usually are not as Good as Weimer's Empirical Convection Electric Field Model**
- **The Addition of Ionospheric O^+ was a Major Advance**
- **$P = C\rho^{\gamma}$ as an Energy Equation is too Simple**

What is Needed from the Magnetosphere Community

Need to Improve the Energy Equation in the Global MHD Magnetosphere Models to Include Collisionless and Wave-Induced Heat Flow

What is Needed from the Magnetosphere Community

20 km Spatial Resolution and 1 Minute Temporal Resolution

Need to Separately Model H^+ (solar wind), H^+ (polar wind) and H_S (neutral polar wind)

Need to Separately Model the Different Hot Electron Populations (Polar Rain, Squall & Drizzle)

Need to Determine the Stability of the Magnetosphere in the Presence of Non-Maxwellian Polar Wind Velocity Distributions

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